

Figure of merit for HBD cuts

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Figure of merit from efficiency and rejection: Assumptions

- ▶ The only efficiencies and rejections considered are those coming from the HBD
- ▶ If the number of signal pairs within the acceptance is $n_{sig}(m_{ee})$, and the efficiency for singles is ε_{sig} , then, the number of HBD vetted signal pairs is given by

$$N_{sig}(m_{ee}) = \varepsilon_{sig}^2 R_{sig} n_{sig}$$

$n_{sig}(m)$ can be calculated in exodus for example or taken from run4 measurement appropriately scaled.

- ▶ From the same exodus simulation, one can get a p_T distribution of electrons from decays (signal) and scale with the appropriate factors to get inclusive p_T distribution of generated signal $n_{e^+/e^-}(m_{ee})$ to get the number of reconstructed pairs $N_{e^+/e^-}(p, \theta, \phi)$.
 - ▶ An acceptance filter
 - ▶ Background rejection filter, assuming the rate of backplane conversion misidentification ε_{bg0} and the rate of beam pipe and dalitz misidentification ε_{bg2}
- ▶ This $N_{e^+/e^-}(p, \theta, \phi)$ distribution is then used as a random number generator to create a background distribution.

$$N_{bg}(m) = N_{e^+}(p, \theta, \phi) \otimes N_{e^-}(p, \theta, \phi)$$

Reconstructed signal and background rates

The number of reconstructed signal pairs is

$$N_{sig} = \varepsilon_{sig}^2 R_{sig} n_{sig}$$

So, the number of reconstructed foreground pairs is :

$$N_{bg}(m) = N_{e+}(p, \theta, \phi) \otimes N_{e-}(p, \theta, \phi)$$

where

$$N_{e+}(p, \theta, \phi) = N_{e-}(p, \theta, \phi) = \frac{1}{2}(\varepsilon_{sig} n_{sig} \rho_{sig} + \varepsilon_{bg0} n_{bg0} \rho_{bg0} + \varepsilon_{bg2} n_{bg2} \rho_{bg2})(p, \theta, \phi)$$

with $\rho = R + \frac{r}{2}$ are estimated from for example from Exodus

Relative error on the signal OR effective signal

$$\frac{\delta(N_{sig})}{N_{sig}} = \frac{\sqrt{(\delta(N_{sig} + N_{bg}))^2 + (\delta(N_{bg}))^2}}{N_{sig}} = \frac{\sqrt{N_{sig} + 2N_{bg}}}{N_{sig}}$$
$$\xrightarrow{pooldepth \rightarrow \infty} \frac{\sqrt{N_{sig} + N_{bg}}}{N_{sig}}$$

This is just statistical error. If normalization error is added:

$$\frac{\delta(N_{sig})}{N_{sig}} = \frac{\sqrt{N_{sig} + N_{bg} + c^2 N_{bg}}}{N_{sig}}$$

Alternatively the effective signal $\frac{1}{\sqrt{S_{eff}}} = \frac{\delta(N_{sig})}{N_{sig}}$, where $c \approx 0.25\%$

$$S_{eff} = \frac{S^2}{S + BG + c^2 BG^2}$$

What is shown:

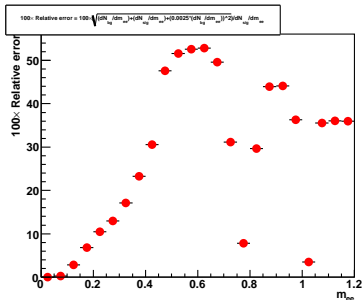
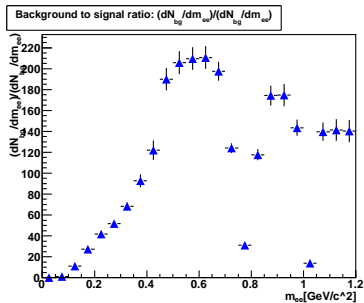
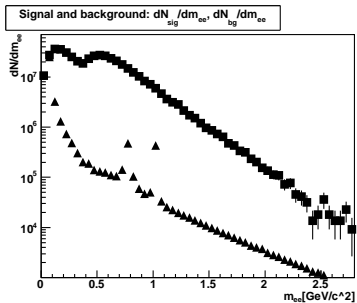
In the following slides, I show:

- ▶ Top left: Fast MC Signal and Background vs. invariant mass
- ▶ Top right: Fast MC Background/Signal ratio
- ▶ Bottom left: Figure of merit ($100 \times \text{Rel. Err}$ or $100 \times \frac{\sqrt{N_{sig} + N_{bg} + c^2 N_{bg}}}{N_{sig}}$)

How run 4 and run 10 are defined.

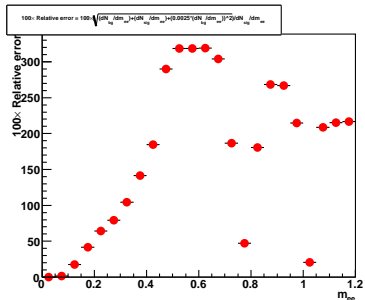
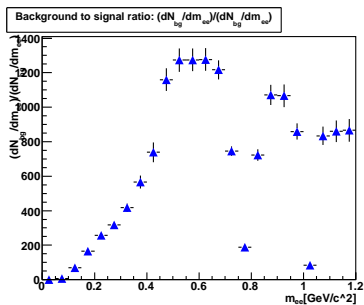
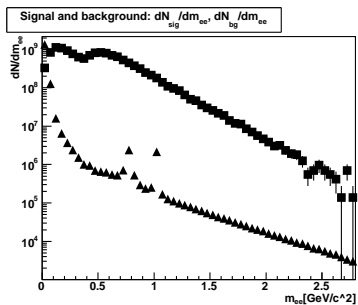
- ▶ For run 4 No HBD, only beam pipe conversion and dalitz and signal electrons. Conversion to dalitz+signal ratio is estimated from Exodus. $N_{evt} = 1 \times 10^9$.
- ▶ For run 10, HBD included, with backplane conversion rate set to $4 \times$ beam pipe conversion rate. In addition, an efficiency factor is introduced for each of signal, backplane and beam pipe conversion types (ϵ_{sig} , ϵ_{bg0} , ϵ_{bg2}), and the above plots are done for different combinations of these efficiencies. $N_{evt} = 5 \times 10^9$.
- ▶ ps: Fast MC (Using Zvi's macros) takes into account hadron misidentification and charm contribution.

Run4, , $n_{bg0} = 0, \varepsilon_{bg2} = 1$



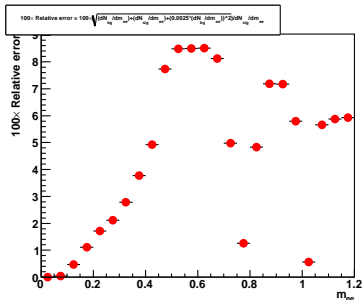
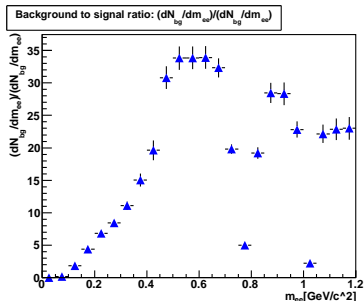
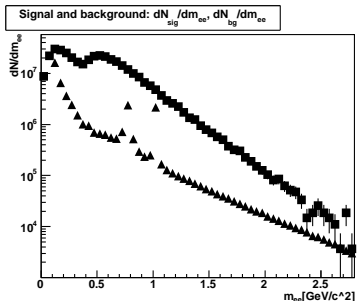
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Run10, no HBD rejection, $\varepsilon_{sig} = 1.0$, $\varepsilon_{bg0} = 1.0$, $\varepsilon_{bg2} = 1.0$.

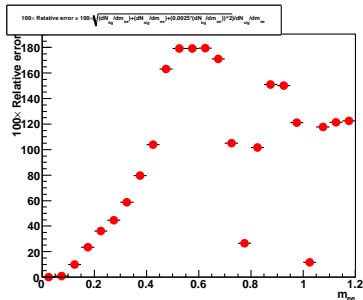
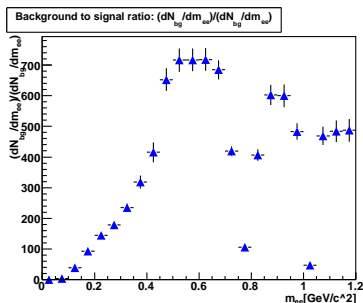
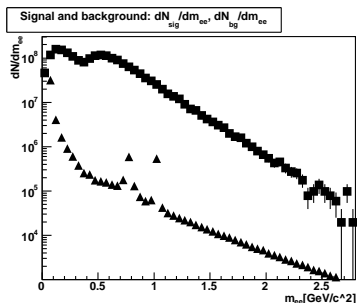


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Run10, perfect HBD rejection $\varepsilon_{sig} = 1.0$, $\varepsilon_{bg0} = 0$, $\varepsilon_{bg2} = 0$.

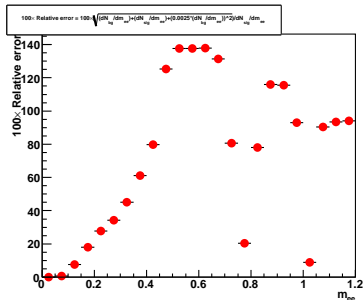
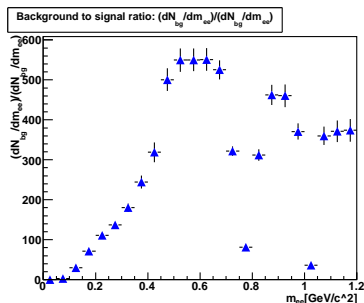
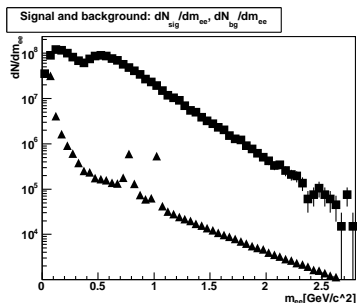


Run10, HBD \approx current status $\varepsilon_{sig} = 0.5$, $\varepsilon_{bg0} = 0.1$, $\varepsilon_{bg2} = 0.5$.



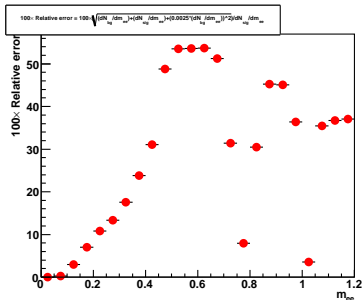
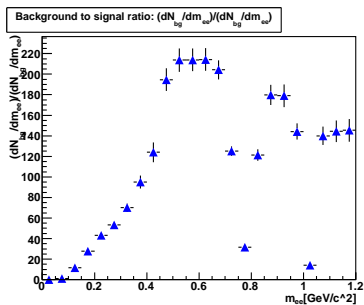
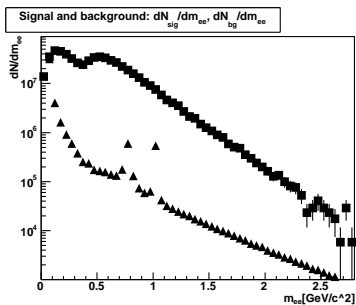
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Run10, $\varepsilon_{sig} = 0.5$, $\varepsilon_{bg0} = 0.01$, $\varepsilon_{bg2} = 0.5$.

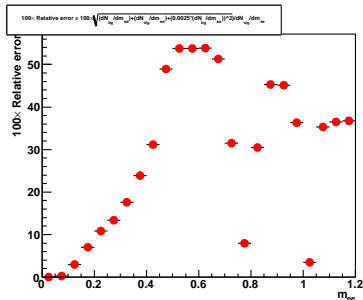
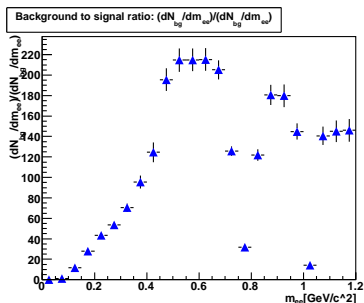
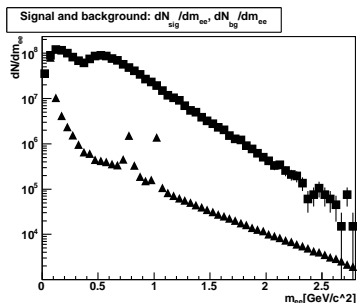


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Run10, $\varepsilon_{sig} = 0.5$, $\varepsilon_{bg0} = 0.05$, $\varepsilon_{bg2} = 0.05$.

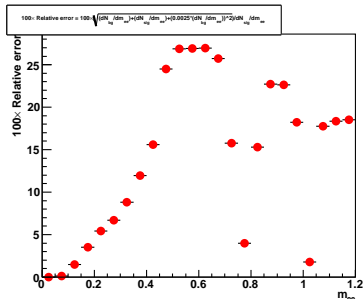
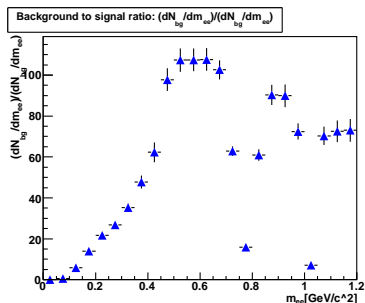
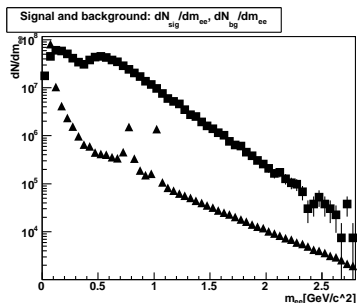


Run10, $\varepsilon_{sig} = 0.8$, $\varepsilon_{bg0} = 0.01$, $\varepsilon_{bg2} = 0.5$.



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Run10, $\varepsilon_{sig} = 0.8$, $\varepsilon_{bg0} = 0.01$, $\varepsilon_{bg2} = 0.2$.



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Summary

- ▶ Suggested way of estimated the figure of merit for HBD cuts
- ▶ Using Run4 settings seem to have a reasonable s/b and relative error as compared to published results
- ▶ But adding the HBD (with the backplane conv.) the relative error is degraded, and was able to get an improvement over the run 4 relative error only with excellent background rejection levels and good efficiency.
- ▶ Will make a 3d map in $(\epsilon_{sig}, \epsilon_{bg0}, \epsilon_{bg2})$ of what the figure of merit should be for a set of these values, which will allow to benchmark different algorithms and cuts.